

What is claimed is:

3        1. In a data packet transmission system, a method of filtering an incoming data packet  
4        comprising the steps of:

5              creating a decision graph having a tree-like hierarchy for a set of filters such that  
6        the filters are subdivided and grouped along edges and stages of the tree-like hierarchy  
7        according to common filter values;

8              receiving a data packet at a point of ingress to the data packet transmission system;

9              comparing filters along edges of the tree-like hierarchy to portions of the data  
10      packet to determine where there are matches; and

11              if matches are made along an entire edge of the tree-like hierarchy, filtering the data  
12      packet stream according to number of condition values compared.

13        2. The method according to claim 1, wherein said creating step is performed so that  
14        the tree-like hierarchy includes wildcards at specified byte values.

15        3. The method according to claim 2, wherein said creating step is performed by the  
16        step of subdividing the set of filters according to common values at specified bytes of said  
17        filters.

1        4. The method according to claim 3, wherein the comparing step further comprises the  
2        step of dynamically choosing which byte of a filter to compare against portions of the  
3        classification key.

1        5. The method according to claim 4, further comprising the step of choosing a next  
2        byte to compare based on the number of wildcards in a filter.

1       6.     The method according to claim 5, further comprising the step of choosing the byte  
2     with the most wildcards.

1       7.     The method according to claim 1, further comprising the step of classifying the data  
2     packet according to the number of condition value matches encountered during  
3     comparison with the tree-like hierarchy.

1       8.     The method according to claim 1, wherein the condition values are limited by a  
2     number of bytes in a filter within the groups of filters.

1       9.     The method according to claim 1, wherein a size of the tree-like hierarchy is  
2     minimized based on a specified criteria.

1       10.    The method according to claim 9, wherein the specified criteria is based on a  
2     number of irrelevant condition values in the data packet stream.

1       11.    The method according to claim 1, wherein the step of creating a decision tree is  
2     performed such that the set of filters are divided into groups of filters based on specific  
3     bytes in a search key.

1       12.    The method according to claim 11, wherein the set of filters are divided based on  
2     comparing one byte at a time in the search key.

1       13.    The method according to claim 1, wherein the filter conditions are divided into  
2     groups of filters based on a maximum number of bits which all filters in the groups of filters  
3     have in common.

1       14. The method according to claim 1, further comprising:  
2              storing intermediate matching values; and  
3              matching the stored results with a next byte of the data packet.

1       15. In connection with a router that receives incoming packets from a data network, a  
2       method of filtering the incoming packets at the interface of the router to provide  
3       differentiated services, the method comprising the steps of:  
4              constructing a decision tree structure that stores a set of filters in a tree-like  
5       hierarchy, the tree-like hierarchy including edges and stages, the set of filters subdivided  
6       according to their values along the edges and stages of the tree-like hierarchy;  
7              the interface of the router receiving at least one incoming data packet; and  
8              comparing segments of the incoming data packet to values of the filters stored in  
9       the tree-like hierarchy such that the segments are compared along stages and not every  
10       edge of the tree-like hierarchy to allow the incoming data packet to be differentiated  
11       according to matches between the segments compared and specific filter values.

1       16. The method of claim 15 wherein said comparison step further comprises the step  
2       of executing a single instruction within the PPU that filters the incoming data packet  
3       according to its content.

1       17. The method of claim 16 wherein the step of executing the single instruction further  
2       comprises the step of advancing from the beginning of the incoming data packet by a  
3       predetermined amount of offset before beginning to compare.

1       18. The method of claim 15 wherein said comparing step comprises the further steps  
2       of:

3              comparing a first specific byte of the incoming data packet to values of filters in the  
4       upper most stage of the tree-like hierarchy;

5              once a match is made, comparing a second specific byte of the incoming data  
6       packet to values of filters contained in a stage below the upper most stage of the tree-like  
7       hierarchy and along edges that connect to filters in the upper most stage that match in  
8       values to the first specific byte.

1       19. The method of claim 18 further comprising the step of comparing further bytes of  
2       the incoming data packets to values of filters contained in subsequent stages of the tree-  
3       like structure until a match is made at the lowest stage of the tree-like structure or no  
4       match at all.

1       20. The method of claim 19 wherein said comparing steps further comprise the step of  
2       dynamically choosing the next byte of the incoming data packet to compare.

1       21. The method of claim 19 wherein said comparing steps further comprise the step of  
2       replacing specified values in the filters with wildcards.

1       22. The method of claim 19 wherein said comparing steps further comprise the step of  
2       collapsing values in any stage of the tree-like structure so that multiple branches from a  
parent can lead to the same child.

1       23. A router for use in a data network and for allowing the implementation of  
2 differentiated services by filtering incoming data packets, the router comprising:  
3              an interface to the data network;  
4              a packet processing unit coupled to said interface and adapted for receiving  
5 incoming data packets via the interface from the data network;  
6              memory means operably coupled to said packet processing unit and adapted for  
7 storing software instructions that cause said packet processing unit to filter incoming data  
8 packets; and  
9              a data structure for storing a set of filters in a tree-like hierarchy, the tree-like  
10 hierarchy including edges organized into stages, the set of filters subdivided according to  
11 their values along the edges and stages of the tree-like hierarchy;  
12              wherein said software instructions are further adapted to cause said packet  
13 processing unit to compare segments of incoming data packets to values of the filters  
14 stored in the tree-like hierarchy such that the segments are compared along stages and  
15 not every edge of the tree-like hierarchy to allow the incoming data packet to be  
16 differentiated according to matches between the segments compared and specific filter  
17 values.

1       24. The router of claim 23 wherein said packet processing unit is an application specific  
2 integrated circuit or general purpose CPU.

1       25. The router of claim 24 wherein said application specific integrated circuit is further  
2 adapted to filter incoming IP packets based on the contents of the IP packets and using  
3 said tree-like structure to provide differentiated services.

1       26. The router of claim 23 wherein said software instructions comprise a single  
2 instruction capable of causing said packet processing unit to filter incoming data packets.

1       27. The router of claim 23 wherein said software instructions are further adapted to  
2       cause said packet processing unit to compare specific bytes of incoming data packets with  
filter values of said tree-like structure.

1       28. The router of claim 27 wherein said software instructions are further adapted to  
2       cause said packet processing unit to compare a first specific byte of the incoming data  
3       packet to values of filters in the upper most stage of the tree-like hierarchy and once a  
4       match is made to compare a second specific byte of the incoming data packet to values  
5       of filters contained in a stage below the upper most stage of the tree-like hierarchy and  
6       along edges that connect to filters in the upper most stage that match in values to the first  
7       specific byte.  
5th  
6th  
7th  
8th  
9th  
10th  
11th  
12th  
13th  
14th  
15th  
16th  
17th  
18th  
19th  
20th  
21st  
22nd  
23rd  
24th  
25th  
26th  
27th  
28th  
29th  
30th  
31st  
32nd  
33rd  
34th  
35th  
36th  
37th  
38th  
39th  
40th  
41st  
42nd  
43rd  
44th  
45th  
46th  
47th  
48th  
49th  
50th  
51st  
52nd  
53rd  
54th  
55th  
56th  
57th  
58th  
59th  
60th  
61st  
62nd  
63rd  
64th  
65th  
66th  
67th  
68th  
69th  
70th  
71st  
72nd  
73rd  
74th  
75th  
76th  
77th  
78th  
79th  
80th  
81st  
82nd  
83rd  
84th  
85th  
86th  
87th  
88th  
89th  
90th  
91st  
92nd  
93rd  
94th  
95th  
96th  
97th  
98th  
99th  
100th  
101st  
102nd  
103rd  
104th  
105th  
106th  
107th  
108th  
109th  
110th  
111st  
112nd  
113rd  
114th  
115th  
116th  
117th  
118th  
119th  
120th  
121st  
122nd  
123rd  
124th  
125th  
126th  
127th  
128th  
129th  
130th  
131st  
132nd  
133rd  
134th  
135th  
136th  
137th  
138th  
139th  
140th  
141st  
142nd  
143rd  
144th  
145th  
146th  
147th  
148th  
149th  
150th  
151st  
152nd  
153rd  
154th  
155th  
156th  
157th  
158th  
159th  
160th  
161st  
162nd  
163rd  
164th  
165th  
166th  
167th  
168th  
169th  
170th  
171st  
172nd  
173rd  
174th  
175th  
176th  
177th  
178th  
179th  
180th  
181st  
182nd  
183rd  
184th  
185th  
186th  
187th  
188th  
189th  
190th  
191st  
192nd  
193rd  
194th  
195th  
196th  
197th  
198th  
199th  
200th  
201st  
202nd  
203rd  
204th  
205th  
206th  
207th  
208th  
209th  
210th  
211st  
212nd  
213rd  
214th  
215th  
216th  
217th  
218th  
219th  
220th  
221st  
222nd  
223rd  
224th  
225th  
226th  
227th  
228th  
229th  
230th  
231st  
232nd  
233rd  
234th  
235th  
236th  
237th  
238th  
239th  
240th  
241st  
242nd  
243rd  
244th  
245th  
246th  
247th  
248th  
249th  
250th  
251st  
252nd  
253rd  
254th  
255th  
256th  
257th  
258th  
259th  
260th  
261st  
262nd  
263rd  
264th  
265th  
266th  
267th  
268th  
269th  
270th  
271st  
272nd  
273rd  
274th  
275th  
276th  
277th  
278th  
279th  
280th  
281st  
282nd  
283rd  
284th  
285th  
286th  
287th  
288th  
289th  
290th  
291st  
292nd  
293rd  
294th  
295th  
296th  
297th  
298th  
299th  
300th  
301st  
302nd  
303rd  
304th  
305th  
306th  
307th  
308th  
309th  
310th  
311st  
312nd  
313rd  
314th  
315th  
316th  
317th  
318th  
319th  
320th  
321st  
322nd  
323rd  
324th  
325th  
326th  
327th  
328th  
329th  
330th  
331st  
332nd  
333rd  
334th  
335th  
336th  
337th  
338th  
339th  
340th  
341st  
342nd  
343rd  
344th  
345th  
346th  
347th  
348th  
349th  
350th  
351st  
352nd  
353rd  
354th  
355th  
356th  
357th  
358th  
359th  
360th  
361st  
362nd  
363rd  
364th  
365th  
366th  
367th  
368th  
369th  
370th  
371st  
372nd  
373rd  
374th  
375th  
376th  
377th  
378th  
379th  
380th  
381st  
382nd  
383rd  
384th  
385th  
386th  
387th  
388th  
389th  
390th  
391st  
392nd  
393rd  
394th  
395th  
396th  
397th  
398th  
399th  
400th  
401st  
402nd  
403rd  
404th  
405th  
406th  
407th  
408th  
409th  
410th  
411st  
412nd  
413rd  
414th  
415th  
416th  
417th  
418th  
419th  
420th  
421st  
422nd  
423rd  
424th  
425th  
426th  
427th  
428th  
429th  
430th  
431st  
432nd  
433rd  
434th  
435th  
436th  
437th  
438th  
439th  
440th  
441st  
442nd  
443rd  
444th  
445th  
446th  
447th  
448th  
449th  
450th  
451st  
452nd  
453rd  
454th  
455th  
456th  
457th  
458th  
459th  
460th  
461st  
462nd  
463rd  
464th  
465th  
466th  
467th  
468th  
469th  
470th  
471st  
472nd  
473rd  
474th  
475th  
476th  
477th  
478th  
479th  
480th  
481st  
482nd  
483rd  
484th  
485th  
486th  
487th  
488th  
489th  
490th  
491st  
492nd  
493rd  
494th  
495th  
496th  
497th  
498th  
499th  
500th  
501st  
502nd  
503rd  
504th  
505th  
506th  
507th  
508th  
509th  
510th  
511st  
512nd  
513rd  
514th  
515th  
516th  
517th  
518th  
519th  
520th  
521st  
522nd  
523rd  
524th  
525th  
526th  
527th  
528th  
529th  
530th  
531st  
532nd  
533rd  
534th  
535th  
536th  
537th  
538th  
539th  
540th  
541st  
542nd  
543rd  
544th  
545th  
546th  
547th  
548th  
549th  
550th  
551st  
552nd  
553rd  
554th  
555th  
556th  
557th  
558th  
559th  
560th  
561st  
562nd  
563rd  
564th  
565th  
566th  
567th  
568th  
569th  
570th  
571st  
572nd  
573rd  
574th  
575th  
576th  
577th  
578th  
579th  
580th  
581st  
582nd  
583rd  
584th  
585th  
586th  
587th  
588th  
589th  
590th  
591st  
592nd  
593rd  
594th  
595th  
596th  
597th  
598th  
599th  
600th  
601st  
602nd  
603rd  
604th  
605th  
606th  
607th  
608th  
609th  
610th  
611st  
612nd  
613rd  
614th  
615th  
616th  
617th  
618th  
619th  
620th  
621st  
622nd  
623rd  
624th  
625th  
626th  
627th  
628th  
629th  
630th  
631st  
632nd  
633rd  
634th  
635th  
636th  
637th  
638th  
639th  
640th  
641st  
642nd  
643rd  
644th  
645th  
646th  
647th  
648th  
649th  
650th  
651st  
652nd  
653rd  
654th  
655th  
656th  
657th  
658th  
659th  
660th  
661st  
662nd  
663rd  
664th  
665th  
666th  
667th  
668th  
669th  
670th  
671st  
672nd  
673rd  
674th  
675th  
676th  
677th  
678th  
679th  
680th  
681st  
682nd  
683rd  
684th  
685th  
686th  
687th  
688th  
689th  
690th  
691st  
692nd  
693rd  
694th  
695th  
696th  
697th  
698th  
699th  
700th  
701st  
702nd  
703rd  
704th  
705th  
706th  
707th  
708th  
709th  
710th  
711st  
712nd  
713rd  
714th  
715th  
716th  
717th  
718th  
719th  
720th  
721st  
722nd  
723rd  
724th  
725th  
726th  
727th  
728th  
729th  
730th  
731st  
732nd  
733rd  
734th  
735th  
736th  
737th  
738th  
739th  
740th  
741st  
742nd  
743rd  
744th  
745th  
746th  
747th  
748th  
749th  
750th  
751st  
752nd  
753rd  
754th  
755th  
756th  
757th  
758th  
759th  
760th  
761st  
762nd  
763rd  
764th  
765th  
766th  
767th  
768th  
769th  
770th  
771st  
772nd  
773rd  
774th  
775th  
776th  
777th  
778th  
779th  
780th  
781st  
782nd  
783rd  
784th  
785th  
786th  
787th  
788th  
789th  
790th  
791st  
792nd  
793rd  
794th  
795th  
796th  
797th  
798th  
799th  
800th  
801st  
802nd  
803rd  
804th  
805th  
806th  
807th  
808th  
809th  
810th  
811st  
812nd  
813rd  
814th  
815th  
816th  
817th  
818th  
819th  
820th  
821st  
822nd  
823rd  
824th  
825th  
826th  
827th  
828th  
829th  
830th  
831st  
832nd  
833rd  
834th  
835th  
836th  
837th  
838th  
839th  
840th  
841st  
842nd  
843rd  
844th  
845th  
846th  
847th  
848th  
849th  
850th  
851st  
852nd  
853rd  
854th  
855th  
856th  
857th  
858th  
859th  
860th  
861st  
862nd  
863rd  
864th  
865th  
866th  
867th  
868th  
869th  
870th  
871st  
872nd  
873rd  
874th  
875th  
876th  
877th  
878th  
879th  
880th  
881st  
882nd  
883rd  
884th  
885th  
886th  
887th  
888th  
889th  
890th  
891st  
892nd  
893rd  
894th  
895th  
896th  
897th  
898th  
899th  
900th  
901st  
902nd  
903rd  
904th  
905th  
906th  
907th  
908th  
909th  
910th  
911st  
912nd  
913rd  
914th  
915th  
916th  
917th  
918th  
919th  
920th  
921st  
922nd  
923rd  
924th  
925th  
926th  
927th  
928th  
929th  
930th  
931st  
932nd  
933rd  
934th  
935th  
936th  
937th  
938th  
939th  
940th  
941st  
942nd  
943rd  
944th  
945th  
946th  
947th  
948th  
949th  
950th  
951st  
952nd  
953rd  
954th  
955th  
956th  
957th  
958th  
959th  
960th  
961st  
962nd  
963rd  
964th  
965th  
966th  
967th  
968th  
969th  
970th  
971st  
972nd  
973rd  
974th  
975th  
976th  
977th  
978th  
979th  
980th  
981st  
982nd  
983rd  
984th  
985th  
986th  
987th  
988th  
989th  
990th  
991st  
992nd  
993rd  
994th  
995th  
996th  
997th  
998th  
999th  
1000th  
1001st  
1002nd  
1003rd  
1004th  
1005th  
1006th  
1007th  
1008th  
1009th  
10010th  
10011st  
10012nd  
10013rd  
10014th  
10015th  
10016th  
10017th  
10018th  
10019th  
10020th  
10021st  
10022nd  
10023rd  
10024th  
10025th  
10026th  
10027th  
10028th  
10029th  
10030th  
10031st  
10032nd  
10033rd  
10034th  
10035th  
10036th  
10037th  
10038th  
10039th  
10040th  
10041st  
10042nd  
10043rd  
10044th  
10045th  
10046th  
10047th  
10048th  
10049th  
10050th  
10051st  
10052nd  
10053rd  
10054th  
10055th  
10056th  
10057th  
10058th  
10059th  
10060th  
10061st  
10062nd  
10063rd  
10064th  
10065th  
10066th  
10067th  
10068th  
10069th  
10070th  
10071st  
10072nd  
10073rd  
10074th  
10075th  
10076th  
10077th  
10078th  
10079th  
10080th  
10081st  
10082nd  
10083rd  
10084th  
10085th  
10086th  
10087th  
10088th  
10089th  
10090th  
10091st  
10092nd  
10093rd  
10094th  
10095th  
10096th  
10097th  
10098th  
10099th  
100100th  
100101st  
100102nd  
100103rd  
100104th  
100105th  
100106th  
100107th  
100108th  
100109th  
100110th  
100111st  
100112nd  
100113rd  
100114th  
100115th  
100116th  
100117th  
100118th  
100119th  
100120th  
100121st  
100122nd  
100123rd  
100124th  
100125th  
100126th  
100127th  
100128th  
100129th  
100130th  
100131st  
100132nd  
100133rd  
100134th  
100135th  
100136th  
100137th  
100138th  
100139th  
100140th  
100141st  
100142nd  
100143rd  
100144th  
100145th  
100146th  
100147th  
100148th  
100149th  
100150th  
100151st  
100152nd  
100153rd  
100154th  
100155th  
100156th  
100157th  
100158th  
100159th  
100160th  
100161st  
100162nd  
100163rd  
100164th  
100165th  
100166th  
100167th  
100168th  
100169th  
100170th  
100171st  
100172nd  
100173rd  
100174th  
100175th  
100176th  
100177th  
100178th  
100179th  
100180th  
100181st  
100182nd  
100183rd  
100184th  
100185th  
100186th  
100187th  
100188th  
100189th  
100190th  
100191st  
100192nd  
100193rd  
100194th  
100195th  
100196th  
100197th  
100198th  
100199th  
100200th  
100201st  
100202nd  
100203rd  
100204th  
100205th  
100206th  
100207th  
100208th  
100209th  
100210th  
100211st  
100212nd  
100213rd  
100214th  
100215th  
100216th  
100217th  
100218th  
100219th  
100220th  
100221st  
100222nd  
100223rd  
100224th  
100225th  
100226th  
100227th  
100228th  
100229th  
100230th  
100231st  
100232nd  
100233rd  
100234th  
100235th  
100236th  
100237th  
100238th  
100239th  
100240th  
100241st  
100242nd  
100243rd  
100244th  
100245th  
100246th  
100247th  
100248th  
100249th  
100250th  
100251st  
100252nd  
100253rd  
100254th  
100255th  
100256th  
100257th  
100258th  
100259th  
100260th  
100261st  
100262nd  
100263rd  
100264th  
100265th  
100266th  
100267th  
100268th  
100269th  
100270th  
100271st  
100272nd  
100273rd  
100274th  
100275th  
100276th  
100277th  
100278th  
100279th  
100280th  
100281st  
100282nd  
100283rd  
100284th  
100285th  
100286th  
100287th  
100288th  
100289th  
100290th  
100291st  
100292nd  
100293rd  
100294th  
100295th  
100296th  
100297th  
100298th  
100299th  
100300th  
100301st  
100302nd  
100303rd  
100304th  
100305th  
100306th  
100307th  
100308th  
100309th  
100310th  
100311st  
100312nd  
100313rd  
100314th  
100315th  
100316th  
100317th  
100318th  
100319th  
100320th  
100321st  
100322nd  
100323rd  
100324th  
100325th  
100326th  
100327th  
100328th  
100329th  
100330th  
100331st  
100332nd  
100333rd  
100334th  
100335th  
100336th  
100337th  
100338th  
100339th  
100340th  
100341st  
100342nd  
100343rd  
100344th  
100345th  
100346th  
100347th  
100348th  
100349th  
100350th  
100351st  
100352nd  
100353rd  
100354th  
100355th  
100356th  
100357th  
100358th  
100359th  
100360th  
100361st  
100362nd  
100363rd  
100364th  
100365th  
100366th  
100367th  
100368th  
100369th  
100370th  
100371st  
100372nd  
100373rd  
100374th  
100375th  
100376th  
100377th  
100378th  
100379th  
100380th  
100381st  
100382nd  
100383rd  
100384th  
100385th  
100386th  
100387th  
100388th  
100389th  
100390th  
100391st  
100392nd  
100393rd  
100394th  
100395th  
100396th  
100397th  
100398th  
100399th  
100400th  
100401st  
100402nd  
100403rd  
100404th  
100405th  
100406th  
100407th  
100408th  
100409th  
100410th  
100411st  
100412nd  
100413rd  
100414th  
100415th  
100416th  
100417th  
100418th  
100419th  
100420th  
100421st  
100422nd  
100423rd  
100424th  
100425th  
100426th  
100427th  
100428th  
100429th  
100430th  
100431st  
100432nd  
100433rd  
100434th  
100435th  
100436th  
100437th  
100438th  
100439th  
100440th  
100441st  
100442nd  
100443rd  
100444th  
100445th  
100446th  
100447th  
100448th  
100449th  
100450th  
100451st  
100452nd  
100453rd  
100454th  
100455th  
100456th  
100457th  
100458th  
100459th  
100460th  
100461st  
100462nd  
100463rd  
100464th  
100465th  
100466th  
100467th  
100468th  
100469th  
100470th  
100471st  
100472nd  
100473rd  
100474th  
100475th  
100476th  
100477th  
100478th  
100479th  
100480th  
100481st  
100482nd  
100483rd  
100484th  
100485th  
100486th  
100487th  
100488th  
100489th  
100490th  
100491st  
100492nd  
100493rd  
100494th  
100495th  
100496th  
100497th  
100498th  
100499th  
100500th  
100501st  
100502nd  
100503rd  
100504th  
100505th  
100506th  
100507th  
100508th  
100509th  
100510th  
100511st  
100512nd  
100513rd  
100514th  
100515th  
100516th  
100517th  
100518th  
100519th  
100520th  
100521st  
100522nd  
100523rd  
100524th  
100525th  
100526th  
100527th  
100528th  
100529th  
100530th  
100531st  
100532nd  
100533rd  
100534th  
100535th  
100536th  
100537th  
100538th  
100539th  
100540th  
100541st  
100542nd  
100543rd  
100544th  
100545th  
100546th  
100547th  
100548th  
100549th  
100550th  
100551st  
100552nd  
100553rd  
100554th  
100555th  
100556th  
100557th  
100558th  
100559th  
100560th  
100561st  
100562nd  
100563rd  
100564th  
100565th  
100566th  
100567th  
100568th  
100569th  
100570th  
100571st  
100572nd  
100573rd  
100574th  
100575th  
100576th  
100577th  
100578th  
100579th  
100580th  
100581st  
100582nd  
100583rd  
100584th  
100585th  
100586th  
100587th  
100588th  
100589th  
100590th  
10059